Center Innovation Fund: ARC CIF

Collective Robotic Assembly of Discrete Lattice Elements (CRADLE)

Completed Technology Project (2017 - 2018)

Project Introduction

CRADLE seeks to address this need through a novel application of an integrated robot-structure-material system based on discrete lattice construction using task specific robots. Bolting mechanisms from SOA platforms will be modified to fit mobile robot. Lattice element/hardware pickup station and/or mobile cassettes will be designed. LiPo batteries and radio communications will enable untethered experiments. Initial autonomy will require error detection, this can be achieved through current sensing of motors and controls algorithms for error correction. And each robot will have pre-determined build sequence while collaborating on large scale construction. It is possible to address agent-based swarm system with inter-robot sensing and communication.

Anticipated Benefits

This work relates to Agency Initiatives as follows: Aeronautics: robotic assembly, inspection, repair, and maintenance of discrete lattice structures for aircraft systems such as lighter-than-air airships or long-duration atmospheric satellites. Science: robotic assembly of dishes, antennae, or other science mission platforms with apertures/baselines larger than current SOA capabilities. Exploration: Automated assembly of large space structures enables repairable, large-scale, deep-space habitats and vehicles that can allow humans to live indefinitely outside Earth. While previous work on task-specific robots for lattice structures has shown success in microgravity on parabolic flights through the external Flight Opportunities program, the limited time in microgravity (<20s) will not be sufficient for an automated assembly experiment. We are therefore seeking an experiment on a Suborbital Reusable Launch Vehicle (sRLV) P1 Flight Profile (as described here: https://www.nasa.gov/directorates/spacetech/flightopportunities/opportunities), which can provide >2 min of continuous micro-g. This would enable an experiment with numerous sequential autonomous maneuvers. Once the TRL is sufficiently high, we would be in position to propose an extended experiment on the ISS, LOP-G, or lunar surface. This would enable a relatively large structure (on the order of 1m) to be autonomously assembled. This would then be extended to external experiments, possibly in the form of a cubesat or small satellite.

Collective Robotic Assembly of Discrete Lattice Elements

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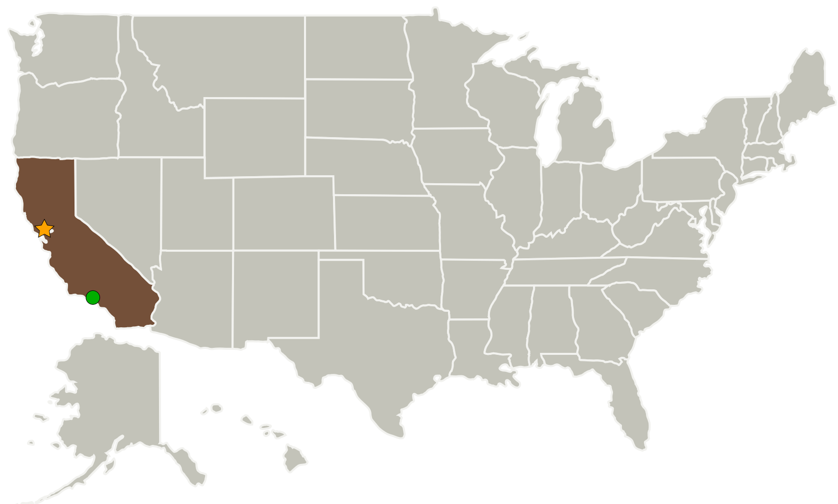
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
☆Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
●Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
Massachusetts Institute of Technology(MIT)	Supporting Organization	Academia	Cambridge, Massachusetts

Primary U.S. Work Locations
California

Project Transitions

October 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

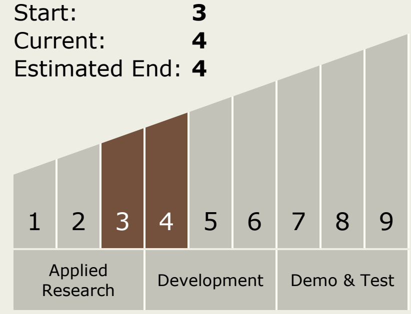
Harry Partridge

Principal Investigator:

Kenneth C Cheung

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



September 2018: Closed out

Closeout Summary: The ability to cost effectively manufacture very large spac e structures enables higher performance for a variety of missions, such as com munication antennas and space telescopes, large surface area for energy collecti on, or habitats for long distance travel. Achieving this large scale is an ongoing c hallenge for space exploration and operations. Deployable structures are limited to the mass and volume constraints of a single launch vehicle. Alternatively, on orbit construction promises the bypassing of launch load limits, with gradual buil ding of structures larger than those achievable in a single launch. However, this does not currently take advantage of the recent renaissance in automation capa bilities afforded by the scaling of sensing, computing, and electromechanical har dware brought on by consumer product manufacturing automation and embedd ed electronics in consumer products themselves. Collective Robotic Assembly of Discrete Lattice Elements (CRADLE) applies the benefits of automation cost scali ng observed in industry to space structures manufacturing through a novel appli cation of an integrated robot-structure-material system based on discrete lattice construction using task specific robots.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - └─ TX07.2 Mission Infrastructure, Sustainability, and Supportability
    - └─ TX07.2.4 Micro-Gravity Construction and Assembly

Target Destinations

Earth, The Moon, Others Inside the Solar System